First mirror tests for ITER: influence of material choice on the deposition/erosion mechanisms affecting optical reflectivity

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Almost all optical diagnostics systems on ITER will be based on in-vessel metallic first mirrors [1]. The possible deterioration of their surface reflectivity as a result of erosion by charge-exchange neutrals and re-deposition of material eroded from the plasma-facing components [2] represents a serious concern for the reliability of spectroscopic and laser signals. A concerted effort within the tokamak community has been initiated to characterize these effects and seek mitigation methods. To date, these different damaging (erosion and deposition) effects have always been considered independently, neglecting any role that may be played by the substrate. In this contribution, we attempt to assess the influence of substrate material using both laboratory simulation experiments and mirror exposures in the TCV tokamak. Our results have potentially important implications for the ITER first-mirror choice.

In TCV, which has nearly 90% first wall coverage by graphite armour, mirror samples prepared from different materials (Mo, W, Si) are installed on a specially designed manipulator allowing their insertion into the divertor floor region. The samples are recessed behind the front surfaces of the divertor tiles to avoid direct plasma impact, with most exposures being integrated across short periods of 2-3 weeks tokamak operation, including regular helium glow discharge cleaning. Under similar exposure conditions, the mirror substrate has been found to strongly influence the thickness of deposited layers found on the sample. For example, the carbon layer thickness on a silicon sample was found to be five times higher than on a molybdenum substrate.

In the laboratory, mirrors made from a variety of ITER-relevant materials (Cu, Stainless steel, Mo) are being exposed to a low temperature deuterium plasma with controlled partial pressures of methane in the gas mixture. Sample reflectivities are monitored *in-situ* during plasma exposure. Mass measurements are subsequently used to determine the eroded/deposited layer thickness, whilst spectrophotometry, spectroscopic ellipsometry and scanning electron microscopy are employed to check the effect of the exposure on the surface morphology and optical properties. Under similar conditions, markedly different erosion/deposition patterns are observed on the different materials. For a methane content of 3.5 % in the gas mixture, Cu is eroded due to physical sputtering by the plasma ions, but a thick a:CH film is found on the stainless steel mirror.

Numerical simulations using the Monte Carlo code Tridyn give results for Mo and stainless steel in good agreement with the experimental findings. For copper, however, simulation cannot yet reproduce experiment. This may be indicative of chemical effects (neglected in Tridyn) such as carbide formation or ion recombination occurring at the sample surface playing an important role.

[1] A. Costley *et al*. Fusion Eng. And Des. 55 (2001) 331.

[2] V.S. Voitsenya *et al*, Rev. Sci. Instrum. 72 (2001) 475.